OVEN & LAVA Subsystems in the RESOLVE Payload for Resource Prospector

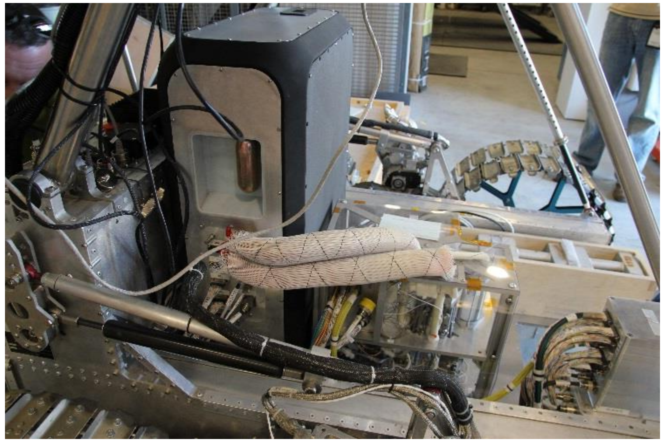
OVEN – JSC

LAVA – KSC with JPL

Level 1 Requirements Trace to OVEN/LAVA

1.2 RESOURCE PROSPECTOR SHALL BE CAPABLE OF OBTAINING KNOWLEDGE ABOUT THE LUNAR SURFACE AND SUBSURFACE VOLATILES AND MATERIALS

- Full Success Criteria: Take both ***sub-surface measurements of volatile constituents via excavation and processing*** and *surface measurements*, at multiple locations
- Minimum Success Criteria: Take either ***sub-surface measurements of volatile constituents via excavation and processing*** or surface measurements, at multiple locations



RESOLVE Payload Hardware for Field Demonstration in 2012

Processing & Analysis

Oxygen & Volatile Extraction Node (OVEN)
- **Volatile Content Extraction by warming**
- **Total sample mass**

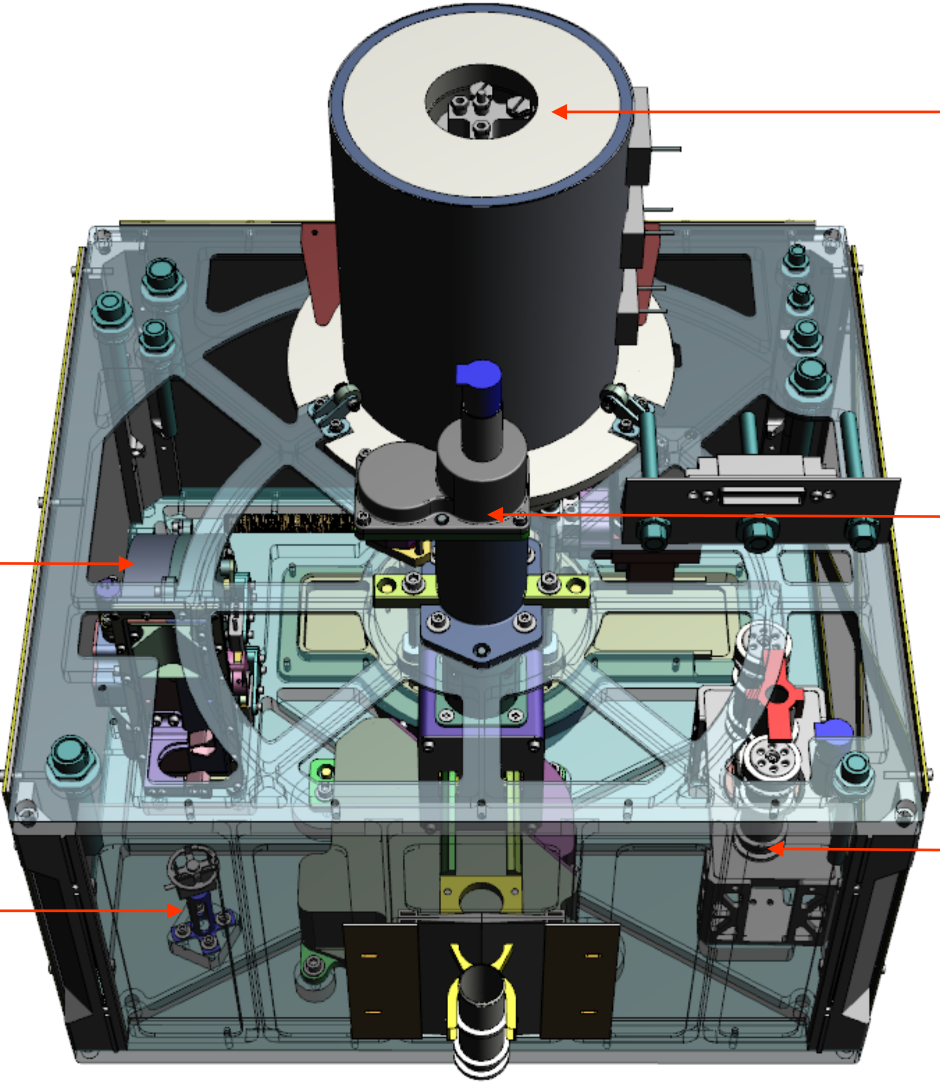
Lunar Advanced Volatile Analysis (LAVA)
- **Analytical volatile identification and quantification in delivered sample with GC/MS**
- **Measure water content of regolith at 0.5% (weight) or greater**
- **Characterize volatiles of interest below 70 AMU**

Oxygen & Volatile Extraction Node (OVEN)

Multiple functions

- Receive sample from drill
- Weigh sample pre and post processing
- Heat sample, build pressure from volatiles
- Transfer volatile sample to LAVA Subsystem
- Discard sample

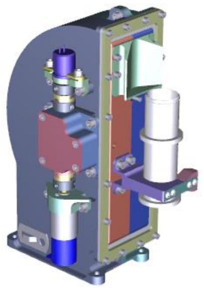
OVEN Demonstration Unit for RP-15



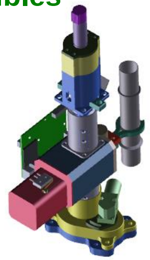
REGOLITH SAMPLE INLET
Drill Interface

REACTOR STATION
Elevates/Seals/Heats Regolith Samples

REMOVAL STATION
Discards Regolith Samples

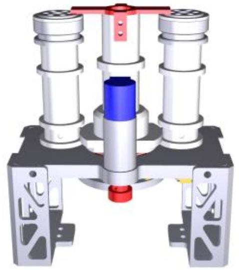


ARM
Rotates/Elevates/Extends Crucibles



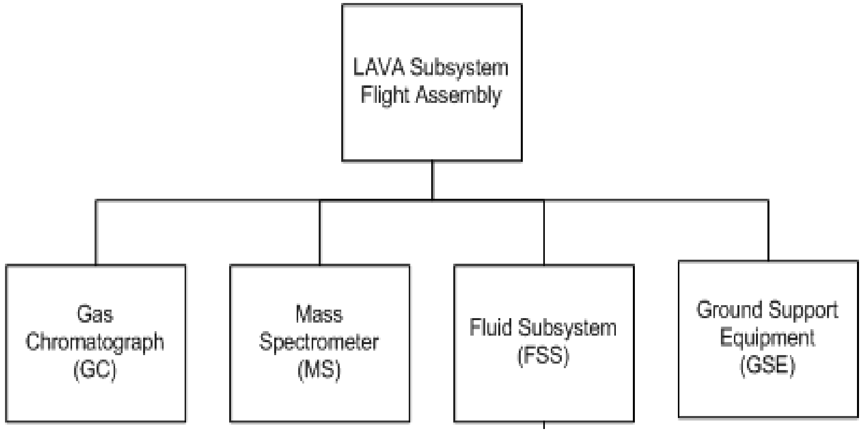
WEIGH STATION
Weighs Regolith Samples

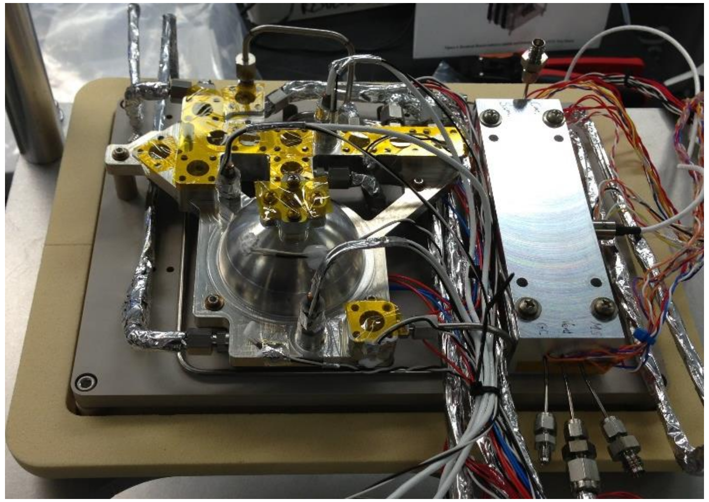
STORAGE STATION
Stores 2 Crucibles

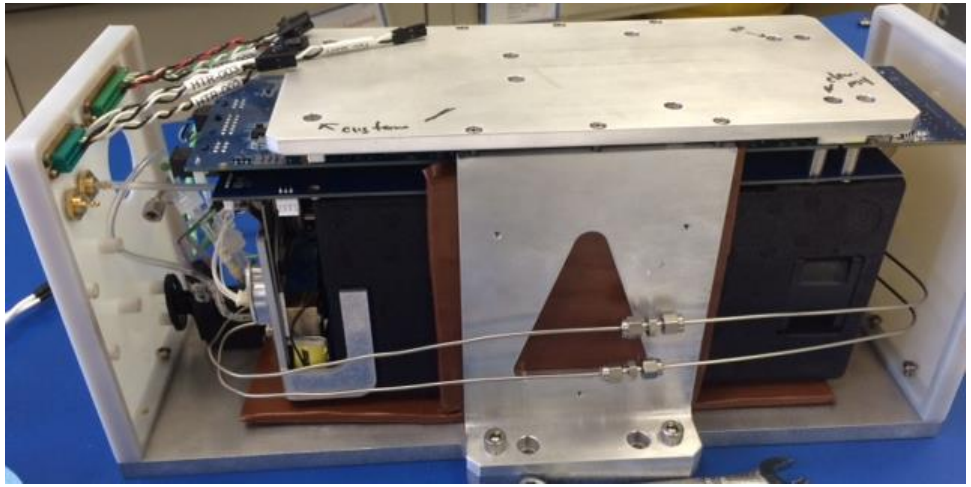


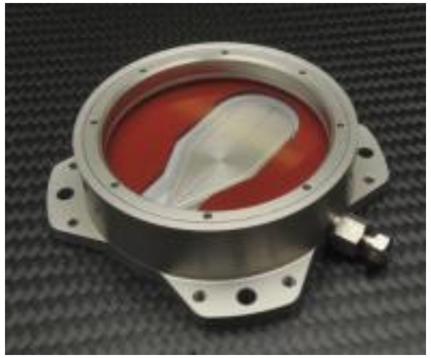
Lunar Advanced Volatile Analysis (LAVA)

- Purpose: Identify and quantify water as well as other low molecular weight species of interest to ISRU and Science community
    - Volatiles are stored in Surge Tank where the Pressure & Temperature are measured, gas sample analyzed by GC-MS to identify constituents.
    - Gases of interest are H_2O, CO, CO_2, H_2, H_2S, NH_3, SO_2, CH_4, C_2H_4.
    - Water that is evolved will be condensed and photographed, demonstration of resource storage.









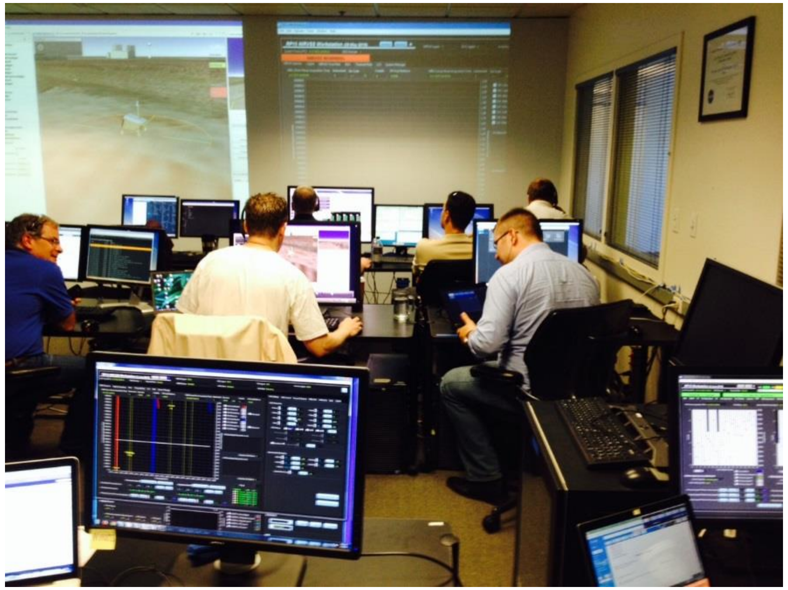
LAVA Physical Architecture - Flight

Operations

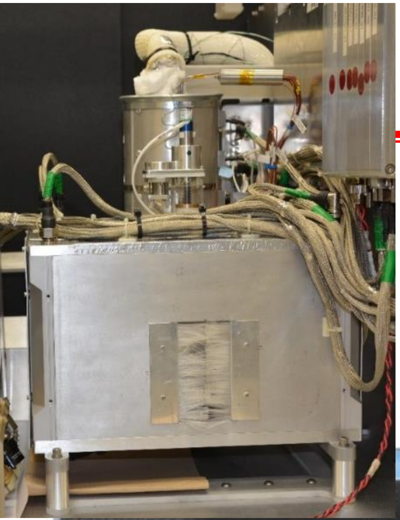
- Automated operations using Virtual Machine Language (VML), which has been used in previous flight missions
- Using flight-forward payload and ground software with our development hardware allowed for very early software validation, operator training, remote instrument integration and distributed control capability
- Distributed ops between labs, integrated payload hardware, and operational tests against system models are used throughout the payload development

KSC Firing Room 4 Control Room

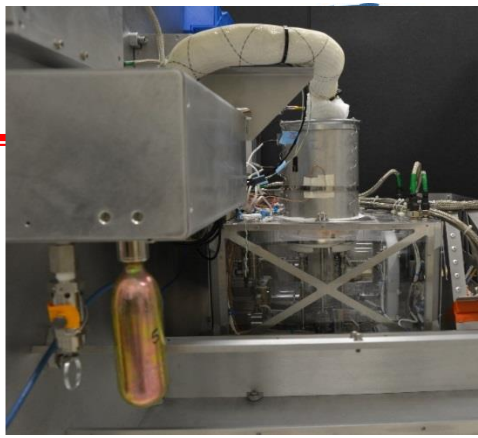
Payload Integrated Test on Rover at JSC



ARC Control Room

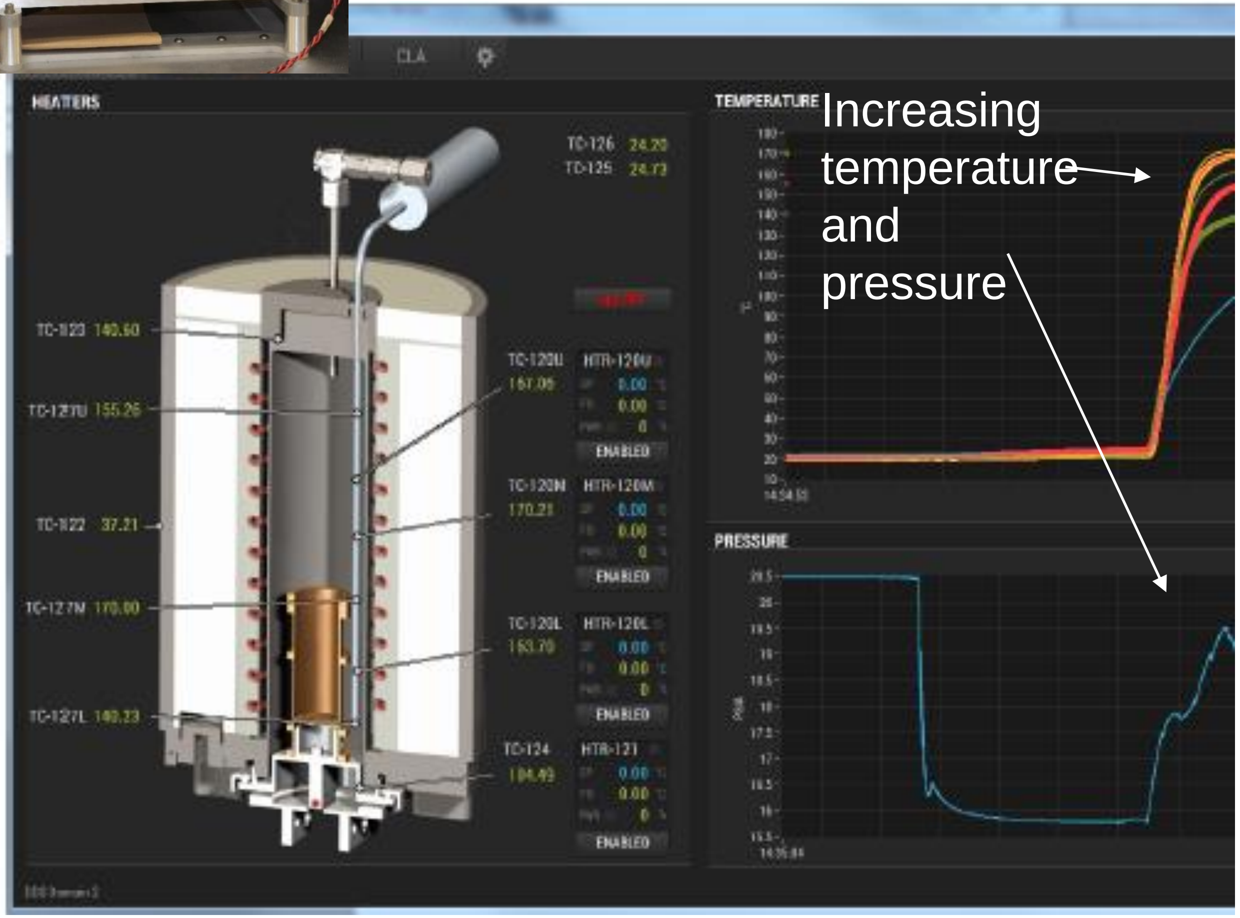


OVEN-LAVA Data for RP-15 Volatile Analysis

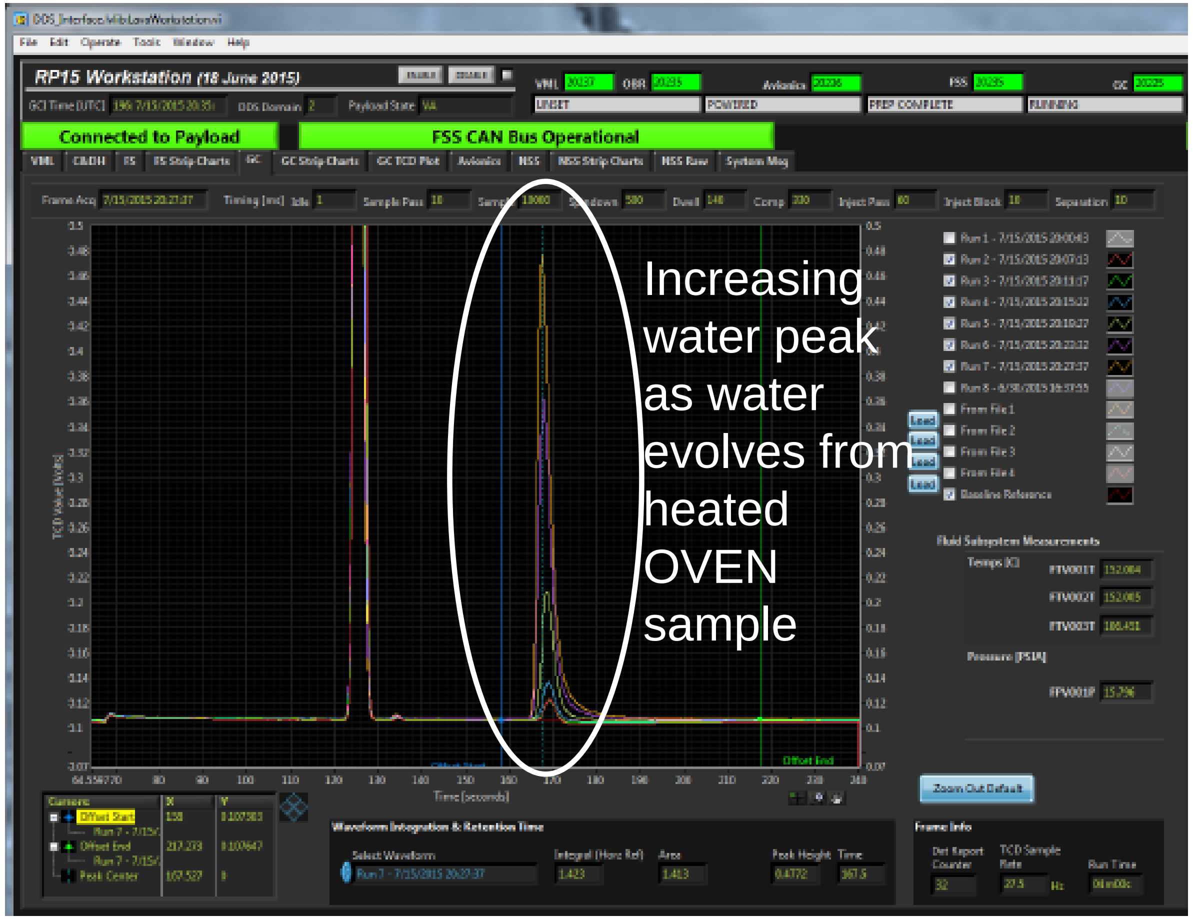


RP-15 Limited instrument applicability due to atmosphere

Volatile analysis demonstration analyzing measured increasing water concentration as simulant sample temperature increases



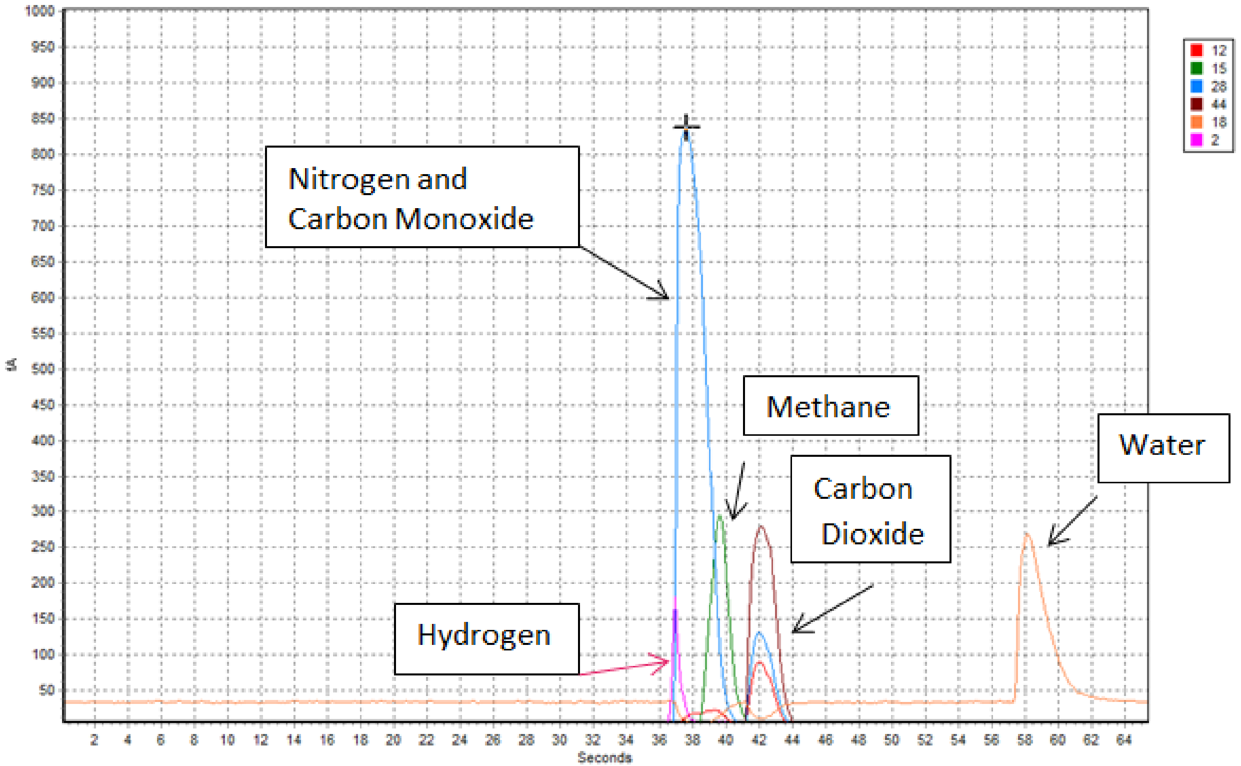
OVEN User Interface

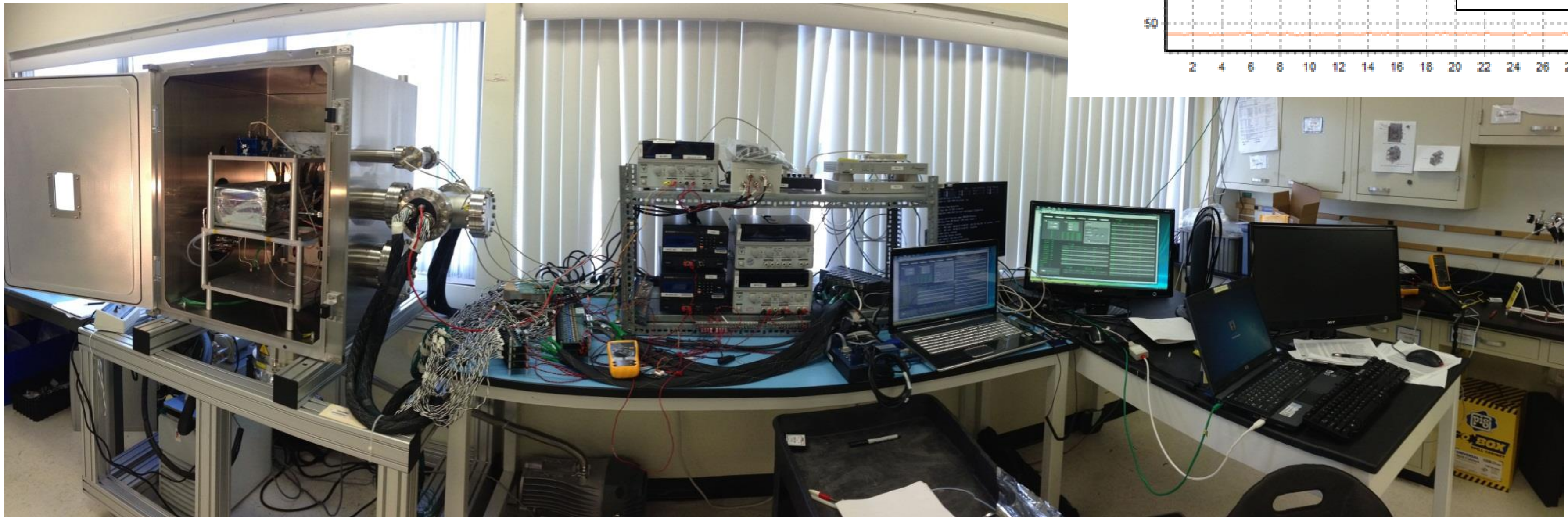


LAVA GC User Interface

Flight forward design – modified COTS

- Utilize components from other missions where possible within schedule/cost
- Raise TRL by testing in thermal vacuum chamber (more flight like for subsystem until integrated payload and rover tests in vacuum)
- Integrated LAVA hardware testing with Payload Software and Avionics at KSC, GC-MS at JPL

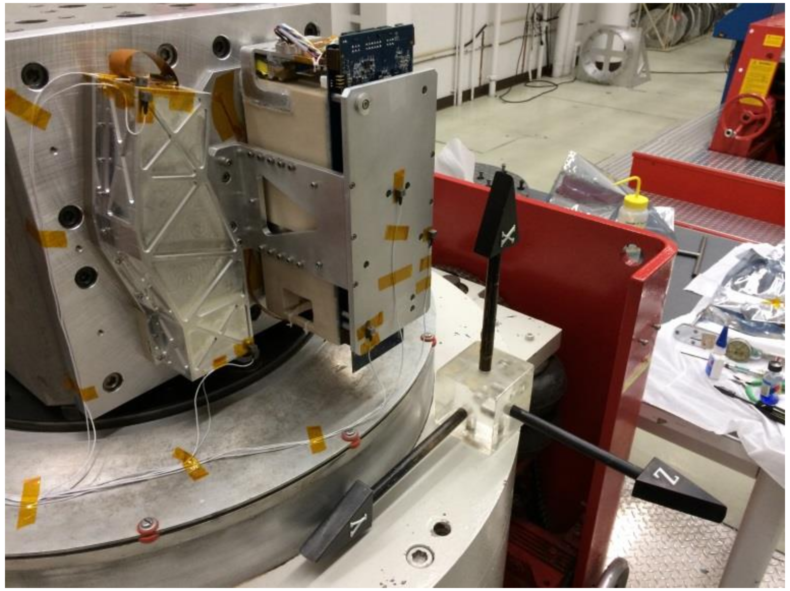




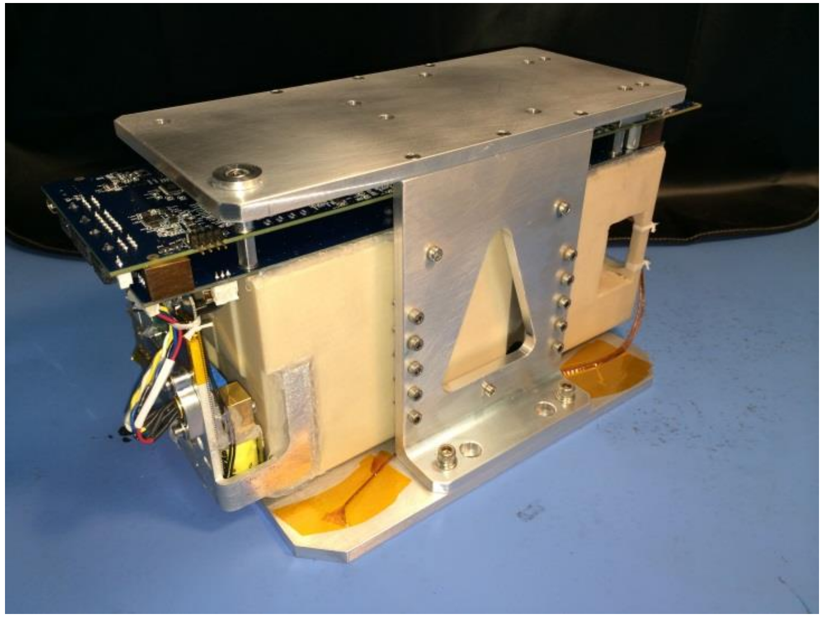
Modified COTS Vibration Testing

- Random Vibration testing (FY14):
  - Completed design/construction of ‘modified COTS’ GC.
  - Completed vibe testing of mass spec and GC at JPL.
  - Both mass spec and GC pass post-vibe limited functional tests.
  - Now TRL6 mass spec: engineering model tested in relevant environment. Design essentially locked.
  - TRL5/6 GC: “brassboard +” tested in relevant environment, but design changes likely.

3-axis 14.1grms random vibe at JPL

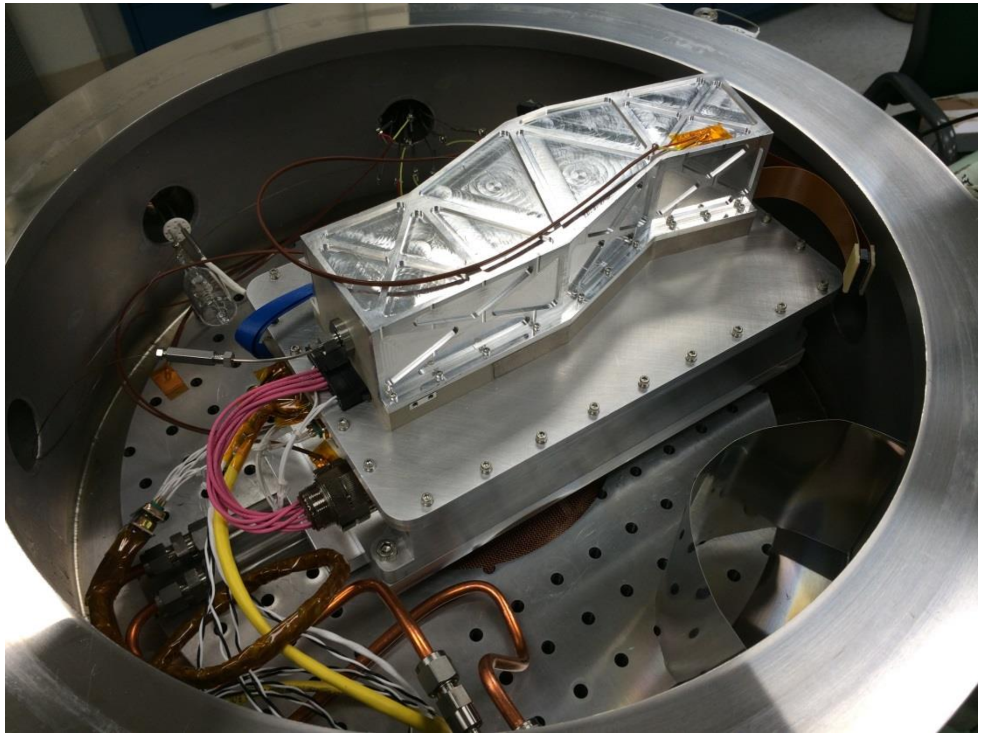


Modified COTS GC

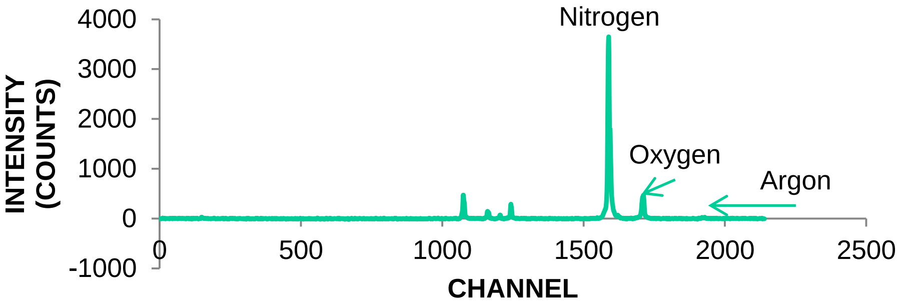


RP LAVA GCMS Summary

- Accomplishments:
- VDU Mass Spectrometer:
  - Integrated electronics and mass spec into bell jar. MILESTONE
  - Test data produced: Verified operation in vacuum of system
  - MS is TRL6, Electronics TRL5 [needs vibe test], System is TRL5.
- Low-mass electronics enclosure:
  - Layup tool being fabricated.
  - Design being analyzed.
  - Expect ~40% reduction in mass of final assembly using the pre-preg carbon fiber material vs aluminum.
- Plans:
  - Complete fabrication of layup tool (June) & procure material
  - Lay up of carbon composite electronics enclosure (July-August)
  - Gather and repeat mass spec test data (June – September)



***RP20 Mass spectrometer** with electronics in vacuum chamber, ready for testing.*

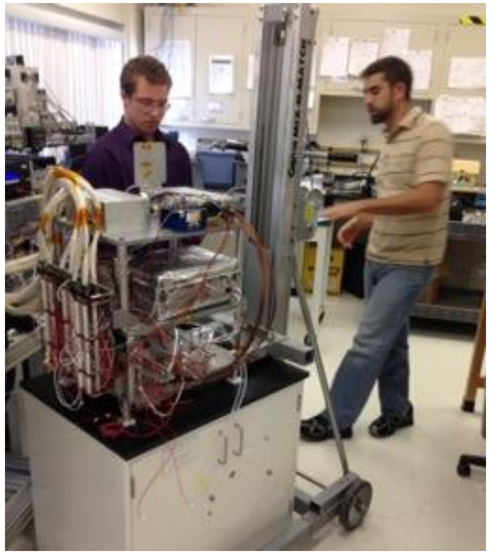


***Mass spectrum of air** measured using TRL5 mass spectrometer system.*

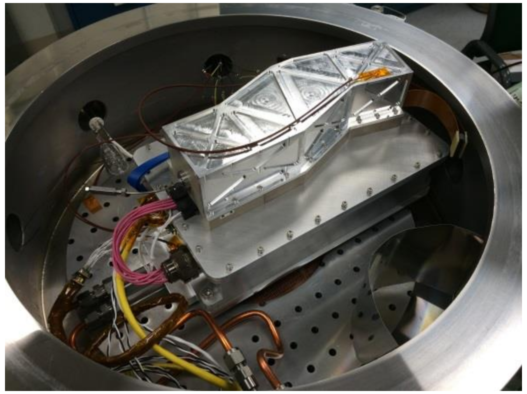
Current Status and Future Work

- Integrated LAVA-OVEN test of flight-like design tested in thermal vacuum chamber that includes OVEN reactor and LAVA fluid subsystem manifold, water droplet demonstration, gas chromatograph and mass spectrometer
- Two COTS mass spectrometers under evaluation that have data supporting proposed requirements for volatile analysis
- Employing modified COTS, working with vendors closely for instrument and component testing for evaluation and testing
- Working with Science PI/ISRU community to understand analysis priorities and ensure payload can meet quantitation goals

Collaboration with JPL, SBIR companies, and instrument vendors



Integrated Stack ready for install in Vac Chamber



MS system configured in environmental chamber